



Federal Geographic Data Committee

Civil Imagery and Remote Sensing Task Force

Report to the Administration:

Value of Civil Imagery and Remote Sensing

October 1, 2002



FEDERAL GEOGRAPHIC DATA COMMITTEE



Civil Imagery and Remote Sensing Task Force

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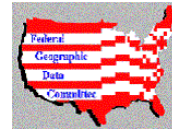


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Civil Imagery and Remote Sensing Task Force

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FEDERAL GEOGRAPHIC DATA COMMITTEE



Civil Imagery and Remote Sensing Task Force

Report to the Administration: *Value of Civil Imagery and Remote Sensing*

Executive Summary

This report illustrates the value of remote sensing to Federal civil agencies in meeting the Nation's economic, land management, emergency management, and infrastructure needs. It notes that the benefits of remote sensing technology are not fully realized because Federal remote sensing activities are often underfunded and lack sufficient administrative structures and incentives that would promote greater interagency collaboration. A sound remote sensing strategy could address these issues by optimizing remote sensing authorities and directives, designating appropriate civil agency leadership roles and authorities, developing innovative funding approaches, and offering administrative enhancements for facilitating governmentwide collaboration. Recommendations are provided within this report for developing the civil component of a national remote sensing strategy. These recommendations include the commissioning of a study¹ on specific policy and administrative solutions to enable increased remote sensing collaboration. The Civil Imagery and Remote Sensing (CIRS) Task Force of the Federal Geographic Data Committee (FGDC) will help develop the civil component of a national remote sensing strategy in concert with national space policy and in cooperation with appropriate Federal forums and communities.

1. Introduction

Federal civil agencies² regularly use remote sensing³ technology to support critical national programs. Remotely sensed data provide geographic information that often could not be acquired, or acquired efficiently, by other means. For example, remote sensing can map and monitor locations that are difficult, expensive, or dangerous to access, such as monitoring the direction and movement of wildfires, yield estimates for foreign wheat crops, and the extent of floodplains or floodwaters. Remote sensing is regularly used to efficiently update basic layers of map information, which in turn are fundamental in enabling quick responses to unexpected disasters. Remote sensing also serves national interests in global monitoring and national security. Section two of this

¹ Suggested independent study by the National Academy of Public Administration at an estimated cost of \$300,000.

² The Federal Geographic Data Committee represents 17 Federal agency members (www.fgdc.gov).

³ Remote sensing refers to the art and science of collecting information about an object from a distance. Remotely sensed data originates as energy that is reflected or emitted by an object and is typically recorded by film or digital sensors. Located aboard aircraft and satellite platforms, these sensors are able to view the Earth's atmosphere, land, and oceans. People and/or computers typically process the remotely sensed data into images or elevation measurements that are analyzed to solve problems described within this report.

report highlights a variety of remote sensing applications to illustrate the critical value of this information to U.S. national interests. Section three provides a conceptual model of how geographic data are converted to a decisionmaking tool within the information lifecycle, section four highlights a sample of underfunded major national programs that rely on remote sensing, and section five provides recommendations for developing a national remote sensing strategy.

2. Value Proposition for Remotely Sensed Data

In 1998, the National Academy of Public Administration reported that \$3.56 trillion of U.S. economic activity is directly related to geographic information,⁴ an indication that geographic data and analysis underpin major components of the American economy and numerous Government functions. Remotely sensed data are inherently rich sources of geographic detail that become even more valuable when referenced to a geographic coordinate system. The geographic nature of remotely sensed data lends itself to ready interpretation through human cognitive abilities to detect and interpret pattern, colors, and shapes. A sample of Government programs that rely on remotely sensed data is shown in Table 1; this list represents only a very small sample of agency programs applying remotely sensed data. Many of these programs have State, local, tribal, and other users and stakeholders. The value of these programs is multiplied to the extent that they meet these needs.

TABLE 1. Sample list of Federal programs that rely on remotely sensed data		
Agency	Program/Activity	Coverage
DOI/USGS	<i>The National Map</i> Gap Analysis Program National Satellite Archive ⁵	United States and Global United States Global
USGS/NPS	Vegetation Mapping Program	United States National Parks
USGS, EPA, USFS, NOAA, NASA, BLM	Multi-resolution Land Characteristics	United States
DOI/FWS	National Wetlands Inventory	United States
USDA/FAS	Global Crop Assessment Program	Global
USDA/FS	Forest Fire Monitoring	Global
USDA/NRCS	National Resources Inventory Soil Survey Conservation Planning	United States and Territories United States and Territories United States and Territories
FEMA	Flood Map Modernization Program HAZUS Risk Assessment Model	United States United States
EPA	Landscape Sciences Program Superfund Program	United States United States

⁴ Geographic Information for the 21st Century, The National Academy of Public Administration, 1988, Washington, D.C.

⁵ National Satellite Land Remote Sensing Data Archive.

NASA	Global Climate Change Solid Earth and Natural Hazards	Global
FGDC	National Spatial Data Infrastructure	United States
USGCRP ⁶	Global Change Research	Global
USACE	Levee Maintenance Program	United States Waterways
Census Bureau	TIGER Program	United States
DOT	Transportation Corridor Planning, Infrastructure Inventory/Management	United States
FAA	Safe Flight 21 Program, Aeronautical Charting Program Instrument Procedure Design	United States United States and Global

For the purposes of this report, the following seven national interest areas were selected to illustrate applications of remotely sensed data:

- Transportation
- Agricultural management
- Environment
- Emergency management and homeland defense
- Energy
- Natural resource management
- Basic and applied scientific research

2.1 Transportation

Increasing trends in population growth and frequency of travel are stressing the capacity of the current transportation infrastructure. The Department of Transportation has recognized the importance of investing in the application of advanced technologies, such as automation, communication, and intelligent transportation systems, to improve the efficiency and increase the capacity of transportation systems. Remotely sensed data support the design, operation, and management of multimodal transportation systems for moving people and freight. For example, in a NASA study of 10 airports, geographic data for synthetic vision systems in aircraft and air traffic control facilities were estimated to provide \$2 billion in savings per year for those airports.⁷ Representative uses of remotely sensed data for transportation include the following:

- Monitoring snow hazards and supporting winter weather services; expected to save several hundred lives and several million dollars of highway maintenance costs annually for transportation agencies.
- Tracking unusual meteorological flight hazards, such as volcanic ash, that affect navigation safety and cause critical jet engine damage.

⁶ U.S. Global Change Research Program.

⁷ Hemm, Robert V. "Benefit Estimates of Synthetic Vision Technology," July 2000, NASA LaRC.

- Developing high-accuracy terrain databases that support ground-warning systems and reduce aviation accidents.
- Locating and charting transportation hazards, such as radio, television, and microwave towers, and low-altitude hazards, such as powerlines, to improve flight safety by developing enhanced instrument flight procedures, and aeronautical charting. To improve flight response times for emergency medical, fire and rescue, and disaster response operations.
- Developing cost-effective corridor planning to relieve congestion around urban areas and avoid environmental impacts. Deploying new tools for regional traffic flow management, including heavy-vehicle flow.
- Developing high-accuracy airport map databases that air traffic controllers and flight crews can use to improve airline traffic flow, relieve airport congestion, and reduce runway incursions.

2.2 Energy

Remote sensing systems and imagery contribute many unique capabilities to the energy industry and national energy interests. Remotely sensed data from multispectral⁸ sensors offer a cost-effective means to save energy and locate new energy sources. Remotely sensed data can be used in the following ways:

- Forecast temperature, precipitation, and river stages to help the energy industry improve electrical-load forecasting and hydropower facility management; potential nationwide savings of over \$1 billion year.
- Increase the accuracy of 30-hour weather forecasts to help municipalities analyze and procure the proper amount of energy for heating and cooling; expected benefit of \$1 billion per year in consumer savings.
- Detect geothermal activity using thermal sensors to identify possible new energy sources.
- Detect oil film on the world's oceans. The National Research Council estimates that the amount of oil that enters the world's oceans annually totals 3 million metric tons.⁹ Oil film can be detected using ultra-violet, blue, and infrared bands from multispectral imagery.
- Detect lineaments, faults, and other geologic structures to assist in the exploration of oil and natural gas deposits, tar sands, or other energy and mineral resources.

⁸ Sensors that capture remotely sensed data at various locations or "bands" within the energy spectrum.

⁹ http://www.esa.int/export/esaCP/Pr_5_1995_i_EN.html

- Detect heat emissions and conduct energy audits of buildings and transformers.

2.3 Agricultural Management

The U.S. Department of Agriculture (USDA) has used imagery and remotely sensed data since the Great Depression. Today, USDA and the agriculture industry are using remotely sensed data to direct multibillion dollar farm programs. Farm managers are beginning to exploit near real-time remotely sensed data to manage resources and adjust crop types in an increasingly competitive agriculture environment. Agricultural management applications using imagery and remotely sensed data include the following:

- Monitor domestic and international commodity conditions and forecast global commodity production representing billions of dollars in trade and food aid. Images from several sensors and platforms at varying resolutions combine with ancillary information to support production estimates, which directly affect food security decisions, domestic and international planting decisions, trade conditions, and commodity prices. The Office of Management and Budget uses the domestic and international production estimates in calculating three of its principal Federal economic indicators.
- Quantify the impact of natural disasters on domestic and international agricultural production. This analysis directly affects domestic and international assistance.
- Predict areas of high risk for livestock disease and food contamination around the globe.
- Assist farmers in determining where and when to apply fertilizer, herbicides, and pesticides, identifying parts of their fields in need of irrigation, and establishing early predictions of yield and harvest quality. These analyses can enable farmers to optimize production factors, which minimizes environmental impacts and maximize profits.
- Improve temperature and precipitation forecasts leading to greater efficiency in chemical spraying and potentially saving \$10-15/acre/application.
- Provide objective, unbiased observations of crop condition, type, and area. The observations support compliance activities and analyses, assist effective and fair management of billions of dollars in agriculture programs, and limit fraud, waste, and abuse of farm program funds.

2.4 Natural Resource Management

Land resource management includes a significant array of applications for remotely sensed data. In rangeland management alone, the U.S. Forest Service estimates that remotely sensed data will save \$6-25 million over a 10-year period. Other programs, such as forest fire support, public land management, and local community planning, will

realize similar savings and improve their management and performance. Natural resource management applications using imagery and remotely sensed data include the following:

- Estimate the snow-water equivalence of the winter snowpack. This information aids prediction of water quantity, drought, riverflow, and flooding in parts of the country.
- Identify impacts from pests and invasive species. The state of Ohio uses remote sensing to detect and treat gypsy moth infestations in its forests. These forests support a \$7 billion/yr industry in Ohio.
- Determine ocean color, sea surface temperature, and wind direction to assist coastal managers in detecting and tracking harmful algal blooms, such as red tides, which can pose threats to public health and the shellfish industry (estimated impacts of \$1 billion over 10 years).
- Monitor and map shorelines for navigation, storm surge forecasting, recreation, and multipurpose resource management. Accurate shoreline elevation information assists in property development along coastlines and the determination of setback lines to reduce coastal hazards.
- Apply coarse-resolution imagery from polar-orbiting satellites to direct fishing vessels toward areas of biological productivity, increasing fishing catch volumes and saving fuel.
- Create vegetation indices that can reveal conditions and trends for national and regional drought, plant health, and fire hazards.
- Efficiently collect natural resource data for the USDA National Resources Inventory over approximately 70,000 sample sites per year. Collecting the data using remotely sensed data versus field ground surveys reduces data collection from 8 hours to 1 hour per site.
- Provide conservation assistance to farmers, ranchers, and other land use decisionmakers.

2.5 Environment

Remotely sensed data are used in environmental management at local, regional, and global scales to document environmental conditions, impacts, and changes. Other applications include environmental modeling, planning, regulation, enforcement, research, and education. In addition, remotely sensed data facilitate safe discovery, removal, and remediation of hazardous sites. Data are applied to studies at various scales. On a broad scale, data support studies on land use, land cover biomass, vegetation classification, seasonal vegetative changes (fire, harvest, development, and disease),

global processes, and pollutant dynamics. At very fine scales, imagery provides detailed information on wetland boundaries, shoreline development, urban expansion, and impaired areas, such as Superfund sites. The information supports sound decisions for protecting the Earth's biodiversity and unique landscapes, identifying critical areas for conservation, and forecasting potential areas for famine. Shown below are some uses of remotely sensed data:

- Assist in the detection and cleanup of oil after marine accidents, which result in the release of 2 million gallons of oil into U.S. waters each year.
- Provide credible evidence to recover millions of dollars from environmental polluters.
- Help determine the rate and direction of growth and urbanization to help planning boards make changes in air quality management plans, park and conservation areas, and storm water runoff management.
- Support water quality assessments and soil erosion studies.
- Monitor the movement of airborne pollutants, such as particulates and ozone, that raise ambient levels of air pollutants and make it more difficult for a city or State to meet air quality standards.

2.6 Emergency Management and Homeland Defense

Emergency management activities can be categorized in terms of planning, readiness, response, and recovery. Emergency management personnel use remotely sensed data in each of these areas for decision support regarding the impacts or potential impacts of disasters. For example, data are used to produce elevation models for determining potential flood hazards. Other models combine hazard data with demographics, structures, and physical infrastructures to determine vulnerability, risk, and potential loss. After flooding occurs, remote sensing is used to determine flood boundaries that aid response and recovery activities and help direct and prioritize assistance programs. Remote sensing is also used to inventory critical infrastructure, such as power installations, for homeland security purposes. Both civil remote sensing information and foreign intelligence were critically important in the response and recovery efforts following the events of September 11, 2001. Emergency management applications include the following examples:

- Provide improved weather forecasts and severe weather warnings that would benefit offshore drilling operations by reducing delays in drilling operations and production shutdowns – each shutdown day costs oil and gas companies \$15 million.
- Assist international relief efforts, as was the case in Kosovo, Albania. Where local infrastructure is unfamiliar to foreign relief providers, and where local

government authority has collapsed, photomaps can help route relief deliveries, allocate relief from various foreign donors, and even locate intact warehouses or schools suitable for the dry and secure storage of relief supplies.

- Assess building-by-building earthquake damage to determine the amount of temporary shelter and reconstruction materials needed and to give precise locations regarding where it is needed.
- Assist emergency management agencies and insurance companies in estimating the losses associated with natural disasters, such as floods, hurricanes, earthquakes, fires, and landslides.
- Support flood-hazard analysis by developing updated flood-risk information for the Nation. Over the next 10 years, this information will avert \$360 million Disaster Relief Fund Losses to new infrastructure, public facilities, and buildings. A total of \$45 billion in damage avoidance is expected over a 50 year period.
- Provide a visual intelligence component that when combined with other geographic data, can be useful in modeling potential outcomes of attacks by weapons of mass destruction. For a given hazardous agent, managers can use air-and-water dispersion models to anticipate population impacts and mortality.
- Help plan for safety and security at significant events and operations, including air defense, Super Bowl, port security, counter-terrorism surveillance, inaugurations, transportation network security, air shows, and the Olympics.

2.7 Basic and Applied Scientific Research

In addition to the operational uses of imagery and remote sensing systems described above, civil agencies conduct and sponsor significant amounts of basic and applied research on global climate change and other important aspects of earth science. Within the civil community, the United States spends more than \$2 billion¹⁰ annually on remotely sensed data and data systems. Researchers use remote sensing and imagery at global, regional, and local scales to collect data, monitor conditions, investigate phenomena, and validate measurements. Examples of the use of imagery and remote sensing for scientific research include the following:

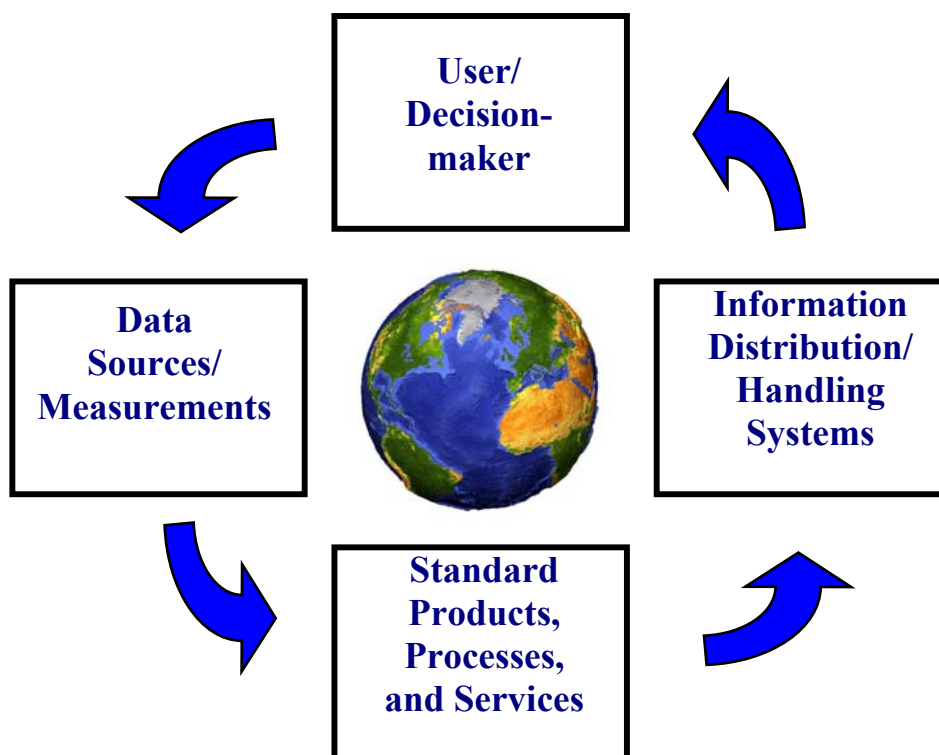
- Resource planning and disaster mitigation rely heavily on weather and climate forecasts. Using remotely sensed data, researchers identified warming patterns in the waters off South America and successfully predicted the 1997-98 El Nino and the subsequent La Nina.

¹⁰ \$1.7 billion supports Global Change Research; see Our Changing Planet, The fiscal year 1998 U.S. Global Change Research Program, <http://www.gcric.org/ocp98/toc.html>.

- Global change research is very dependent upon measurements of atmospheric, oceanic, and terrestrial conditions around the globe. Remote sensing is instrumental in collecting the data to identify and monitor changes.
- Ecological assessments and landscape ecology use imagery and remotely sensed data at local, regional, and national levels.
- Monitoring the stratospheric ozone concentrations is important because ozone is directly related to the amount of ultraviolet radiation that reaches the Earth's surface.
- Monitoring for global warming issues ranges from satellites that provide information on the Earth's energy balance to measurements of the ocean temperature to estimates of the carbon fixation by both terrestrial and aquatic plants.

3. Decision Analysis Cycle: Geographic Data and Information

In the examples above, remotely sensed data were shown to support national needs and decisionmaking by Federal civil agencies, officials, and the public. The following model illustrates the information processes that are needed to ensure the availability of these data, emphasizing that decision support relies on data collection, standards, and information processing systems. The cost of implementing and maintaining this infrastructure is significant, and interoperability between systems operated across the



agencies is critical. Across the Government, disparate needs and systems present challenges to integration and interoperability, and a common reference would serve the development of a coordinated infrastructure that allows each agency to serve its particular mission and share data and technology. Although interoperability across Government agencies is key to achieving homeland security and other national objectives, the budget for providing seamless connectivity is insufficiently allocated in agency appropriations.

A positive development in enhancing interoperability is the FGDC's Geospatial One-Stop¹¹ initiative to accelerate the development of the National Spatial Data Infrastructure (NSDI) framework, including remotely sensed data, and to provide one-stop access to data that conform to a set of common standards. Geospatial One-Stop should benefit all spatial data customers (including Federal, State, local, tribal, and other governments, as well as commercial firms, academia, and private citizens) by providing a common, consistent source of geospatial data. This initiative is one of the 23 e-government initiatives selected by the President's Management Council and will significantly enhance the implementation of e-government.

4. Selected National Programs Reliant on Remote Sensing

The following Federal programs depend on remotely sensed data but will not be able to fully benefit from these data and attendant technologies unless funding shortfalls are eliminated.

4.1 The National Map

The National Map synthesizes base geographic data and derivative products, including topographic maps of the Nation, performs long-term studies of land use changes and their associated consequences, and acquires, processes, and distributes remotely sensed data and products collected by aircraft and satellite. Working through partnerships with other Federal, State, and local governments and the private sector, the U.S. Geological Survey is committed to ensuring the availability of consistent, accurate, and current geographic information to meet national needs, such as land and resource management, response to natural and human-induced disasters, homeland security, infrastructure management, and an array of earth science studies. Geographic information underpins an increasingly significant share of the Nation's economic activity.

Much of the information content of *The National Map* can be derived from remotely sensed data, including the data layers comprising topographic maps, elevation datasets, and national land cover information. The data sources include aerial and satellite imagery, LIDAR, IFSAR, and civil systems, such as Landsat. Although the USGS works through partnerships for data acquisition and sharing, the combined existing funding from Federal, State, and local agencies remains insufficient to provide the Nation with the imagery infrastructure it so urgently needs to accomplish its domestic agenda.

¹¹ <http://www.fgdc.gov/geo-one-stop/index.html>

The need to continually update imagery data requires significant funding. An example is the USGS/NIMA partnership for orthoimagery and feature information data for the 120 most populous U.S. cities (90 metropolitan areas). The 120 Cities Initiative stems from and directly supports ongoing homeland security readiness, response, and recovery requirements. During fiscal year 2002, the USGS and NIMA have committed significant resources to acquire aerial imagery for 45 of the 90 metropolitan areas. The homeland security requirement is ongoing, and meeting this requirement in the future will require repeat acquisitions and considerable additional funding for this part of the orthoimagery component of *The National Map* (the 90 metropolitan areas cover less than 3 percent of the total U.S. land area). Aerial imagery is currently the main imagery source owing to the costs and distribution restrictions associated with licensed satellite data. The core datasets of *The National Map* need to be distributed free of use or distribution restrictions.

4.2 National Shoreline Delineation

Accurately delineating the national shoreline enables the United States to improve the economic efficiency and competitiveness of U.S. maritime commerce, while reducing risks to life, property, and the coastal environment. Today, 98 percent by weight of the Nation's international trade moves through U.S. ports and harbors; 50 fifty percent of these goods are hazardous materials. Over the past 6 years, thirty percent of America's economic gains have resulted from increased exports, and by the year 2020, international trade is expected to increase by 200 percent. However, increased maritime commerce results in increased risks to the coastal environment, making marine navigation safety a serious national concern.

One of the most important tools used by mariners for safe navigation is an accurate nautical chart. The precise placement of the shoreline and port facilities provides a critical piece of information included on these charts. This information is almost exclusively derived from remotely sensed sources. In addition to supporting navigation safety, an accurate national shoreline is key to the economic sustainability and growth of the nation's manufacturing, exporting, coastal development, and insurance industries. A complete up-to-date, consistent, and accurate shoreline map will achieve the following:

- Provide an official U.S. shoreline for a multitude of users.
- Improve electronic charts for navigation. Shoreline depiction is a key element of electronic charts, which if properly used can significantly increase the safety and efficiency of vessel navigation. Safe navigation also helps protect the environment.
- Provide specialized, large-scale shoreline delineation in harbors for the production of docking charts. Docking charts, when used in conjunction with state-of-the-art electronic navigation systems, allow vessels to dock more safely in low-visibility conditions.

- Increase the rate and accuracy of nautical chart revision surveys to keep pace with an accelerated nautical chart publication cycle, and result in more accurate charts for mariners. Provide a smooth, consistent transition between the ocean and land interface for more accurate modeling of storm surge, coastal flooding, and pollution trajectory.
- Increase the content, accuracy, and utility of land and marine geographic information systems (GIS) to support improved management decisionmaking.
- Provide for more accurate environmental analysis and monitoring (for example monitoring marshlands, wetlands, pollution, and sea-level rise; studying coral or aquatic vegetation growth/reduction rates).

Much of the U.S. shoreline data was mapped before 1970. Less than 10 percent of the shoreline has been mapped digitally. At the present rate of progress, it will take 50 years to accurately compile the entire U.S. shoreline. A resurvey cycle of between 5 and 10 years is necessary to ensure that dynamic changes in the shoreline morphology are accurately captured. NOAA's inability to maintain current shoreline data is due to a lack of resources rather than a limitation within the commercial remote sensing sector to meet NOAA's needs.

4.3 National Imagery Collection Programs

Civilian programs that provide national or broad-area standardized imagery coverage have been greatly diminished in recent years. This coverage is essential to support national mapping, environmental, and resource management programs.

As a case in point, the National Aerial Photography Program (NAPP) began in 1988 with an initial goal of acquiring 1:40,000-scale aerial photographs of the conterminous United States every 5 to 7 years. The program goal was to eliminate duplicate acquisition of aerial photographs by individual agencies. Digital copies of NAPP photographs are the primary source for creating orthoimagery for the National Digital Orthophoto Program (NDOP). Orthoimagery now covers almost the entire conterminous U.S. and serves a myriad of resource, planning, and land management activities.

Both the NAPP and the NDOP are examples of national coordination mechanisms to acquire, manage, and disseminate products that adhere to national standards. Cost-share partners include several civil agencies as well as State and local governments. Unfortunately, the NDOP program is failing because of insufficient funding and because agencies are choosing to acquire data that meet their specific versus common requirements. The result is that Federal, State, and local NAPP cooperators are forced to acquire their own imagery at a higher cost rather than waiting for the availability of cooperative funding. When local organizations and independent agencies obtain their own imagery, there is little incentive to adhere to a common NAPP specification for scale, format, or tiling strategy. A related problem is that NAPP specifications have not kept pace with the higher resolution needs of some State and local governments.

Multiple independent imagery projects result in localized nonstandard datasets that are difficult to locate and use, further perpetuating duplication cost increases, all of which hinder the application of these data.

4.4 Flood Mapping Program

In recent years, the Federal Emergency Management Agency's (FEMA) Flood Mapping Program has not met the demand for new maps. In the period from 1982 (when the initial effort of detailed mapping was completed) through 1999, FEMA produced approximately 2,100 map panels each year through the FEMA-funded Flood Data Update Program. During that same period, a backlog of 20,500 map panels with outdated flood data accumulated. Detailed elevation data, which can be obtained using remote sensing, often make up 30 percent of the cost for analyzing flood risks, and this expense is frequently the primary cause of the growing backlog.

Fortunately, in the FY 2003 budget proposal, a major increase in funding is proposed for Flood Map Modernization. If this funding is sustained over several years, it will enable FEMA to obtain the remote sensing data needed to update and modernize the flood maps. However, the map modernization plan expects to rely on up-to-date digital orthophotos for accurate base maps. If the NDOP is not able to provide this imagery, the map modernization plan will face increased costs to obtain suitable base maps independently.

4.5 Farm Records and Compliance Programs

Since the 1930s, the USDA has used aerial photography to record farm ownership and administer farm programs. Photographic enlargements, maintained with pen and pencil, provide the basis for billions of dollars of farm program payments. At current funding levels, the process of transforming these records into more versatile digital layers that can be shared and maintained in a GIS will take many years to complete. As the farm records become digital, the Farm Service Agency's (FSA) yearly 35-mm aerial photographs required for compliance must be converted to GIS-ready digital images.

In terms of source imagery costs, the current analog 35-mm program costs between \$3 and \$5 per square mile. The FSA is in the second year of a new effort that involves contracting for large areas of aerial photography and derived digital imagery that is referenced to the ground. The digital product costs are between \$9 and \$12 per square mile. However, the time saved by using this digital imagery for compliance purposes can easily offset the cost increase compared with 35-mm imagery. The digital imagery will have FGDC-compliant metadata and be in the public domain. The old 35mm program was not FGDC compliant and is difficult to share as a national resource. By contrast, using commercial satellite 1-to-4 meter imagery has proved to be cost prohibitive.

4.6 Global Crop Condition Assessment Program

The USDA's Foreign Agricultural Service (FAS) has used satellite imagery to monitor global crop conditions for almost two decades and has been the largest civil operational user of Landsat imagery. However, the geographic extent of Landsat data collection has been far from comprehensive due to funding constraints. Even without funding constraints, Landsat 7 was not designed to acquire the data volume that the FAS requires. No operational land remote sensing satellites exist or are planned that can fully meet the FAS requirements. In order to be operational, the FAS must exploit imagery from NOAA satellites that were not designed for agricultural monitoring, as well as from short-term NASA research missions that can be terminated when NASA completes its research goals. The lack of a Landsat (or comparable) program that keeps at least two satellites on orbit (to provide 8-day repeat coverage) will greatly reduce the USDA's ability to meet its global food security requirements.

5. Task Force Conclusions and Recommendations

This report provides a snapshot of representative applications of remotely sensed data that are vital to our Nation. However, the greater potential of remotely sensed data and technology for supporting the Nation's economic growth and national security is unrealized because of insufficient resource allocation and the lack of a national remote sensing strategy. The Nation would benefit from a consistent set of policies, strategies and directives for optimizing Governmentwide remote sensing use. Appropriate strategies and implementation plans tied to the budget process would enable interagency collaboration in planning and sharing technology, infrastructure, and data. A sound remote sensing strategy would address gaps in remote sensing authorities, suggest civil agency leadership roles, and formulate innovative administrative and fiscal approaches to increase governmentwide collaboration.

To provide a sound foundation for developing a National strategy, the CIRS Task Force makes the following three recommendations:

1. The Federal Government should conduct a definitive technical review of remote sensing requirements for operational and research needs over the next 5 years. NOAA and the USGS have offered to lead a multiagency team to perform the requirements review and CIRS has offered to oversee the work under its auspices.
2. The National Academy of Public Administration (NAPA) should be commissioned to conduct an investigation to recommend policy and administrative approaches for optimizing Federal remote sensing use through:
 - Improved policies and directives for optimizing civil remote sensing use and providing for the necessary leadership roles to assure long-term continuity in civil access to remotely sensed data and technology.

- Greater collaboration in defining and planning for common long-term remote sensing needs, and in acquiring, managing, and disseminating remotely sensed data.
- New models for placing the most appropriate Government remote sensing research satellites into supported operational programs after the research missions are completed.
- An appropriate lead civil agency (or agency partnership) for operating civil land remote sensing systems and models for funding the proposed lead agency (or agency partnership).

3. The CIRS Task Force should be converted into a permanent FGDC Working Group. The Working Group would commission and oversee the NAPA study on optimizing civil remote sensing, and use the results to help develop the civil component of a national remote sensing strategy in coordination with other appropriate forum and communities.

Appendix A – Other Considerations Relating to a Remote Sensing Strategy

A.1 Some Differences Between the Civilian and Defense/Intelligence Communities

A plan for tighter collaboration between the civil and the Department of Defense (DoD)/intelligence communities needs to account for the inherent differences in their requirements and organizations. For example, DoD/intelligence data requirements are more global in nature and often cover denied areas. When commercial imagery meets DoD mission requirements, the restrictive aspects of data licensing may not present a use impediment, because DoD generally restricts access to its information. However, Executive Order 12906, OMB Circular A-130, and various legislative mandates require that civil agencies broadly share and disseminate information as a public good. Broad data availability enables a number of downstream applications and supports a value-added industry. License agreements, which restrict data use and distribution to a defined user group, present obvious barriers to many civil agencies. Civil agencies traditionally purchase imagery from conventional aerial survey companies that typically sell data without use or distribution restrictions.

A.2 FGDC Framework Data and National Imagery and Mapping Agency Foundation Data Layers

Remotely sensed data are used in the production and maintenance of key datasets, such as the nationally recognized FGDC framework data layers. The widespread availability of framework data layers supports national and regional applications ranging from national defense to infrastructure and resource management, emergency response, mapping, energy, and transportation. The National Imagery and Mapping Agency (NIMA) also produces standardized data layers to support the specific needs of the DoD/intel community, although there are access and use restrictions associated with these data even when they are produced using open sources. The FGDC framework data layers and the NIMA foundation data layers are similar in concept; however, each is produced with different standards, scales, levels of detail, and geographic coverage appropriate to its respective user communities. To better support homeland security activities, the USGS, NIMA, and the FGDC signed a Letter of Intent in October 2001 forming a coalition to develop and execute a plan to acquire, exploit, analyze, maintain, and provide seamless, interoperable geographic information. Both NIMA and the FGDC use imagery, including commercial imagery, in developing parts of their respective data layers. Aerial photography is now the primary source for updating FGDC framework data layers, whereas NIMA primarily uses satellite imagery to create and maintain its foundation data layers.

A.3 Inadequate Funding for Remotely Sensing Data

Among Federal agencies, funds are rarely appropriated specifically for procuring remotely sensed data and services. Even when they are, funding is generally inadequate to allow agencies to exploit commercial data. This problem is widespread and represents a significant obstacle to greater use of commercial imagery. In fact, funding is often

inadequate even for purchasing imagery from Government systems, such as Landsat, at the cost of reproduction. Among other things, this situation reflects a lack of understanding regarding the value of imagery as a source for a myriad of value added applications.

Currently, NASA operates satellites and sensors that can meet some civil agency needs for remotely sensed data (for example, Terra for wildfire detection, tropospheric ozone concentrations, and dust plume monitoring; QuikSCAT for wind profiles and hurricane prediction). Civil agencies are often obliged to acquire these data at no-cost for applications that the satellites were not designed to support, as a way to fill information gaps. This problem is exacerbated when NASA no longer requires a satellite or sensor for research purposes, but civil agencies want continued satellite service for operational applications. No lead agency or department has the recognized authority, responsibility, or budget to drive the research agenda or to move land-observing research satellites and sensors to operational programs. Transferring the responsibility for operating Landsats 5 and 7 from NASA to the USGS is a successful example of this transition, but substantial effort has been required to resolve funding issues.

Furthermore, the private sector does not have a solid business case to launch a commercial land-observing satellite to fill the gap caused by termination of government-operated systems. If such a system were offered, the civil agencies (and to some extent the defense/intelligence community as well) do not have adequate funds to purchase the data. This scenario could result in a gap in the development of knowledge that has been painstakingly developed and demonstrated by NASA research to yield long-term operational benefits. This is not the case for NASA research related to oceans and the atmosphere. As the lead operational agency for those remote sensing activities, NOAA funds and operates satellites that monitor oceans and the atmosphere.

A.4 Rapid Access to Remotely Sensed Data

The value of remotely sensed data to support a decision depends upon the receipt and analysis of that data within the time that the decision window is open. Both the public and private sector providers often have difficulty providing imagery to meet civil community monitoring requirements in a timely manner. Nowhere is this more critical than in responding to natural disasters, such as hurricanes, floods, earthquakes, and volcanic eruptions. Timely delivery is made more challenging by the fact that, in many cases, the data needed for a given problem come from a variety of sources, including existing layers of basic data, data collected for specific applications, or data tied to a particular time or event. For example, synthetic vision systems in aircraft combine terrain data with dynamic weather data to support piloting decisions. For these reasons, a national strategy must include the infrastructure, connectivity, and standards that allow timely data capture and exchange between organizations to meet specific decision timeframes.

A.5 Some Near-Term Trends

The increasing national emphasis on homeland security and the availability of new types of remotely sensed data should fuel increased interest in remote sensing solutions. Even so, the availability of trained personnel to use the data, the costs and complexities of using the data, and the issues of licensing are challenges to be overcome if the benefits of the technology are to be fully recognized. The urgency to satisfy data and information requirements for homeland security should also demand greater cooperation across the combined civil, DoD, intel, and Federal law enforcement communities. Multispectral data sources will increase dramatically, as will the availability of hyperspectral and eventually ultraspectral sensors. The use of commercial sources is also likely to accelerate considerably.

A.6 Congressional Research Service Report on Remote Sensing Use

Future decisions on how to best coordinate and advance the imagery activities of Federal agencies are informed by a variety of studies, such as the Congressional Research Service's (CRS) survey of remote sensing data and technology used by 20 Federal non-military agencies.¹² Congress commissioned the report in order to better understand Federal agency use of remote sensing and the issues that arise in obtaining and applying the technology and data.

The CRS report states that the most frequent remotely sensed data applications were for environmental and conservation purposes, with 10 agencies reporting extensive or moderate use. Seven agencies reported extensive to moderate use of remote sensing for early warning, mitigation, monitoring, and studying the impact from natural disasters. Other uses include basic and applied research, mapping activities, laws and treaties (monitoring and verifying compliance), agricultural activities, and transportation and shipping.

Participating agencies cited many concerns related to the availability, access, and use of remotely sensed data and technology. Of these agencies, 10 reported availability concerns (referring to the problems and difficulties agencies experienced in getting the data needed to carry out specific tasks and missions), 12 reported data access concerns, 9 cited cost and licensing concerns, and 9 reported concerns over their capacity to effectively use and exploit remotely sensed data and technology (mostly because of a shortage of specialized personnel within the agencies).

¹² *Assessment of Remote Sensing Data Use by Civilian Federal Agencies*, Senate Governmental Affairs Subcommittee on International Security, Proliferation, and Federal Services and the Congressional Research Service, December 2001.

Appendix B – August 2001 FGDC Survey

In August 2001, the FDGC conducted a survey of 15 Federal civil agencies to characterize near-term agency requirements for remotely sensed data, and for the 7 geographic data layers of the National Spatial Data Infrastructure (NSDI) framework. Eighty-two unique programs were found to use remotely sensed data and NSDI layers in the following capacities:

<u>NSDI Data Layers</u> <i>Relative use of NSDI Framework Data Layer</i>	<u>NSDI Data Layers</u> <i>Percent of Business Functions Using Multiple NSDI Data Layers</i>
Geodetic Control 51%	5 or more layers..... 38%
Orthoimagery 77%	3 or 4 layers..... 40%
Elevation 62%	2 or fewer layers 22%
Transportation 67%	
Hydrography 65%	Using one or more layers potentially derived from remotely sensed data
Governmental Units 50% 90%
Cadastral..... 33%	

The types of business applications were categorized and tabulated as follows:

- Long-Term Monitoring
 - A. Requirement for daily/hourly observations:
 - 1. Weather
 - 2. Fire
 - 3. Hazards (especially volcanoes)
 - 4. Traffic
 - B. Requirement for weekly/biweekly observations:
 - 1. Agricultural Monitoring
 - C. Requirement for seasonal observations:
 - 1. Global Climate Change
 - D. Requirement for one or two observations per year at specific times.
 - 1. Program Compliance Activities
 - 2. Environmental/Resource inventories
- Long-Term Mapping (State/National/Global)
 - A. Requirement for cloud-free imagery critical to starting projects.
- Disaster Response Activities
 - A. Hourly/Daily/Weekly Monitoring
 - 1. Damage Assessment
 - Public Safety
 - Property Impacts
 - Infrastructure Impacts

Environment Impacts
 Health Impacts
 Food Security Impacts
 2. Disaster Response

In addition, programmatic applications were tabulated according to the geographic extent, frequency of activity, spatial resolution, and timeliness of fulfilling the data request, reflecting a broad diversity of uses. Several of the trends that emerged are an emphasis on regional and national applications, higher resolution imagery, either shorter or longer-term requirements, and various timeframes for repeat coverage.

<u>Characteristics of Applications</u>	
<u>Areal Extent</u>	
Local.....	15%
Regional	24%
National.....	55%
Global.....	6%
<u>Frequency of Observation</u>	
Ad Hoc	19%
Daily/Weekly	12%
Monthly/Seasonally	10%
Annually.....	22%
Multiannually	36%
<u>Spatial Resolution</u>	
Less than 2 meters.....	58%
2-10 meters.....	31%
10-30 meters.....	8%
More than 30 meters	3%
<u>Timeliness Needs for Data Delivery</u>	
Days	26%
Week-Month	25%
Months	9%
More than 6 months	41%
<i>(Totals greater than 100% due to rounding.)</i>	